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TRANSLATOR'S DECLARATION

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solemnly declare:

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PCT International Application PCT/DE2004/002706, filed on December 9, 2004.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: May 18, 2006



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ACCURATE LITERAL TRANSLATION OF PCT INTERNATIONAL APPLICATION
PCT/DE2004/002706 AS FILED ON 9 DECEMBER 2004

GAS TURBINE COMPONENT

The invention relates to a gas turbine component, namely a static gas turbine component.

Modern gas turbines, especially aircraft engines, must satisfy
5 the highest demands with respect to reliability, weight, power, economy, and operating service life. In the last decades, aircraft engines were developed especially in the civil sector, which fully satisfy the above demands and have achieved a high degree of technical perfection. In the development of aircraft
10 engines, among other things, the material selection, the search for new suitable materials, as well as the search for new production methods play a decisive roll.

The most important materials used these days for aircraft engines or other gas turbines are titanium alloys, nickel alloys (also
15 called super alloys) and high strength steels. The high strength steels are used, for example, for compressor housings and turbine housings. Titanium alloys are typical materials for compressor parts. Nickel alloys are suitable for the hot parts of the aircraft engine. Primarily the investment casting as well as the
20 forging are known from the state of the art as production methods for gas turbine components of titanium alloys, nickel alloys or other alloys. All highly loaded or stressed gas turbine

components, such as components for a compressor for example, are forged parts. Components for a turbine, on the other hand, are typically embodied as investment cast parts.

For reducing the weight of gas turbine components, it is already
5 known from the state of the art, to utilize metal matrix composite materials (so-called MMC materials). In such MMC materials, high strength fibers are embedded in the metal material. The production of gas turbine components of such MMC materials is, however, complicated and thus expensive.

10 It is in the sense of the present invention to propose alternative possibilities for weight reduction of static gas turbine components. The mass of the static gas turbine components namely influences the total weight of a gas turbine, especially of an aircraft engine. The more that the weight of
15 the gas turbine components can be reduced, the more advantageous will be the so-called thrust-weight ratio of the aircraft engine, which represents a decisive competitive feature for aircraft engines.

Beginning from this starting point, the problem underlying the
20 present invention is to propose a novel static gas turbine component.

This problem is solved in that the above mentioned gas turbine component is further developed through the features of the characterizing portion of the patent claim 1. According to the

invention, the static gas turbine component is formed at least partially of a metal foam. In the sense of the present invention, it is proposed for the first time to embody static gas turbine components at least partially of metal foam. The use of metal foams enables a cost effective alternative relative to MMC materials and a significant weight savings.

Preferred further developments of the invention arise from the dependent claims and the following description. Example embodiments of the invention are described in further detail, without being limited to this, in connection with the drawing. Therein it is shown by:

Fig. 1 a block circuit diagram for explaining a method for the production of gas turbine components according to the invention;

Fig. 2 a gas turbine component according to the invention embodied as a housing structure according to a first example embodiment of the invention, in a sharply schematized illustration;

Fig. 3 a gas turbine component according to the invention embodied as a housing structure according to a second example embodiment of the invention, in a sharply schematized illustration;

Fig. 4 a gas turbine component according to the invention embodied as a housing structure according to a third example embodiment of the invention, in a sharply schematized illustration;

5 Fig. 5 a gas turbine component according to the invention embodied as a lining or facing of an inlet or intake according to a further example embodiment of the invention, in a sharply schematized illustration;

10 Fig. 6 a gas turbine component according to the invention embodied as an intake lining according to a further example embodiment of the invention, in a sharply schematized illustration;

15 Fig. 7 a gas turbine component according to the invention embodied as an intake lining according to a further example embodiment of the invention, in a sharply schematized illustration;

20 Fig. 8 a gas turbine component according to the invention embodied as an intake lining according to a further example embodiment of the invention, in a sharply schematized illustration;

Fig. 9 a gas turbine component according to the invention, embodied as a pipe line system according to a further

example embodiment of the invention, in a sharply
schematized illustration;

Fig. 10 a gas turbine component according to the invention
embodied as a pipe line system according to a further
example embodiment of the invention, in a sharply
schematized illustration;

Fig. 11 a gas turbine component according to the invention
embodied as a pipe line system according to a further
example embodiment of the invention, in a sharply
schematized illustration;

Fig. 12 a gas turbine component according to the invention
embodied as a pipe line system according to a further
example embodiment of the invention, in a sharply
schematized illustration; and

Fig. 13 a gas turbine component according to the invention
embodied as a pipe line system according to a further
example embodiment of the invention, in a sharply
schematized illustration.

The present invention is described in greater detail in the
following with reference to Figs. 1 to 13, whereby Figs. 2 to 13
respectively show gas turbine components according to the
invention in a strongly or sharply schematized manner. Before
addressing the details of the gas turbine components according

to the invention, however, steps of a preferred production method for static gas turbine components of metal foam shall first be described with reference to Fig. 1.

For producing a static gas turbine component according to the invention for an aircraft engine, one proceeds according to Fig. 1 in such a manner that a metal powder is prepared in a first step 10 and a propellant is prepared in a second step 11. The prepared metal powder is a metal powder on the basis of an aluminum alloy or titanium alloy or nickel alloy. It is also possible to use metal powders on the basis of a cobalt alloy or an iron alloy. Moreover, metal powders of intermetallic titanium-aluminum alloys can be used. Especially titanium hydride is prepared as the propellant.

The prepared metal powder as well as the prepared propellant are mixed in a step 12. The mixture of metal powder and propellant arising after the mixing is then compressed to form a semi-finished part. The compressing can be carried out either in the sense of the step 13 through extrusion, or in the sense of the step 14 through axial hot pressing. At the end of the compression according to step 13 or step 14, thereby a semi-finished part is present, which is visualized through the step 15 in the flow diagram of the Fig. 1. The semi-finished part is externally as good as indistinguishable from a typical metal, however it contains the propellant and can therefore be foamed-up, i.e. is expandable by foaming.

For producing the gas turbine component, the semi-finished part present in the step 15 is warmed or heated in the sense of the step 16, and in particular to just slightly above its melting temperature, so that the metal is melted and a gas evolution or release of the propellant results. Due to the gas evolution of the propellant, the foaming-up or foaming expansion of the semi-finished part is triggered. The foaming-up or foaming expansion is carried out so long until a defined degree of foaming is reached. As soon as this defined degree of foaming is reached, the foaming expansion is ended in that a cooling-off below the melting point of the utilized metal powder occurs. Thereby the foam structure is stabilized. The foaming expansion or foaming-up that was triggered by the heating of the semi-finished part above the melting point of the metal powder, as well as the corresponding ending or terminating of the foaming expansion through cooling-off below the melting point of the metal powder, are visualized together through the step 16. Following the step 16, a surface machining or some other processing or refining treatment of the produced component can still occur in the sense of the step 17. Thus, for example, the component can be connected with a carrier.

Furthermore, Fig. 1 shows, in the sense of a step 18, that further compositional components in addition to the metal powder prepared in the sense of the step 10 and the propellant prepared in the sense of the step 11 can be mixed with the metal powder and the propellant in the step 12. The further compositional components can, for example, be an additional metal powder with

a different melting point or different powder grain size, or a different propellant or also ceramic particles, ceramic fibers or some other inorganic or organic elements.

Fig. 2 shows a first example embodiment of a gas turbine component according to the invention, which forms a housing structure 19, whereby the housing structure 19 is formed at least region-wise, i.e. in partial regions, of metal foam. The housing structure 19 of the Fig. 2 has a first section or region 20 that is formed of metal foam, and a second region 21 that serves as a carrier for the metal foam. In the example embodiment of the Fig. 2, the carrier 21 is arranged on one side of the metal foam 20, whereby the metal foam 20 is fixedly or rigidly connected with the carrier 21. Carrier 21 and metal foam 20 form a simple or single sandwich structure in the example embodiment of the Fig. 2. The carrier 21 further has an angled section 22, whereby the section 22 comprises a bored hole 23 for the connection with other components.

Fig. 3 similarly shows a gas turbine component according to the invention embodied as a housing structure 24, whereby the example embodiment of the Fig. 3 differs from the example embodiment of the Fig. 2 in that a section or region 21 as well as 25 embodied as a carrier is arranged on both sides of the metal foam 20 and is fixedly or rigidly connected with the metal foam 20. The arrangement of the Fig. 3 can also be called a double sandwich construction. The carriers 21 as well as 25 on both sides of the

metal foam 20 can consist of the same or different materials, namely metal alloys.

A further gas turbine component according to the invention embodied as a housing structure 26 is shown in the example embodiment of the Fig. 4, which gas turbine component is similarly formed region-wise of metal foam 20, whereby the metal foam 20 is surrounded on all sides by sections or regions embodied as carriers in the example embodiment of the Fig. 4.

Figs. 5 to 8 show example embodiments of static gas turbine components according to the invention, in which the inventive components form a lining or facing of an inlet or intake, i.e. an intake lining. Thus, Fig. 5 shows a first inventive intake lining 27, that is formed of a metal foam 28, whereby the metal foam 28 is fixedly or rigidly connected with a carrier 29. The intake lining 28 serves for the wear-free or low-wear grazing of a rotating rotor blade 30 of the gas turbine. The intake lining 27 remains stationary or fixed relative to the rotating rotor blade 30 and thus forms a static gas turbine component.

Fig. 6 shows a further intake lining 31, which again is formed of a metal foam 28 and a carrier 29 fixedly or rigidly connected with the metal foam 28. The intake lining 31 of the Fig. 6 also serves for the grazing of radially outer ends of rotating rotor blades of the gas turbine, whereby the carrier 29 of the intake lining 31 of the Fig. 6 takes on a thermal isolation function.

Fig. 7 shows a further inventive intake lining 32, which again consists of a metal foam 28 and a carrier 29 allocated to the metal foam 28 as well as being fixedly or rigidly connected with the metal foam 28. The static or stationary intake lining 32 of the Fig. 7 cooperates with labyrinth seals 33, which are also referred to as seal fins. Such seal fins have different external radii, as is schematically illustrated in Fig. 7, so that the intake lining 32 provided by the metal foam 28 has a stepped contour. The inner diameter of the intake lining 32 provided by the metal foam 28 is adapted or fitted to the outer diameter of the labyrinth seals 33. It is noted that the embodiment of the intake lining 32 according to Fig. 7 is a particularly preferred embodiment of the present invention, because the honeycomb construction of the intake lining known from the state of the art can be replaced with such a metal foam intake lining that cooperates with labyrinth seals. As already mentioned, the metal foam 28 is fixedly or rigidly connected with the carrier 29, especially glued or soldered thereto.

Fig. 8 shows a further inventive intake lining 34, which again is formed of a metal foam 28 and a carrier 29 for the metal foam. In the example embodiment of Fig. 8, openings or bored holes 35 are introduced into the carrier 29. In the sense of the arrows 36, a gas flow can be directed through the bored holes 35 for cooling, whereby in this case, the metal foam 28 is embodied opened-celled or open-pored. Such an open-pored embodied metal foam 28 can be flowed-through by gas. This is indicated by the arrows 37.

Figs. 9 to 13 show further preferred gas turbine components, that are formed region-wise of metal foam, whereby all gas turbine components shown in Figs. 9 to 13 form a pipe line system. In the example embodiment of the Fig. 9, a pipe line system 38 is shown, whereby the pipe line system 38 is formed by a closed-walled pipe 39, which is concentrically enclosed on its outer side by metal foam 40. With such a pipe line system, which consists region-wise of metal foam, improved vibration characteristics as well as thermal isolation characteristics of pipe line systems within gas turbines can be realized. Thereby an ignition or coking of the pipe line system can be prevented.

Fig. 10 shows an embodiment of a pipe line system 41, whereby the pipe line system 41 of the Fig. 10 is again formed by a closed-walled pipe 39, which is surrounded on the outer side by metal foam 40. Fig. 10 makes clear that the metal foam 40 on the outer side of the closed-walled pipe 39 can have any desired arbitrary shape.

The pipe line system 42 illustrated in Fig. 12 differs from the pipe line system 41 of the Fig. 10 in that a securing means 43 is integrated in the metal foam 40. In the sense of the invention, a securing means can be foamed onto the pipe in a simple manner. Hereby the connection with other components is significantly simplified.

Fig. 11 shows an inventive pipe line system 44 which again is formed region-wise of metal foam. In the example embodiment of

the Fig. 11, once again a closed-walled pipe 39 is provided, whereby the pipe 39 in the example embodiment of the Fig. 11 includes a closed inner wall 45 as well as a closed outer wall 46. Thus, in the example embodiment of the Fig. 11, the pipe 39 is embodied double-walled. The metal foam 40 is positioned between the two walls 45 and 46.

A further example embodiment of an inventive pipe line system 47 is shown by Fig. 13, whereby the pipe line system 47 of the Fig. 13 comprises four closed-walled pipes 39 that are positioned together in a metal foam 40. In the example embodiment of the Fig. 13, thus several pipes 39 are combined together by the metal foam 40 to form an integral unit.

At this point it is noted that gas, oil or also propellant can be directed through the pipe line systems of the Figs. 9 to 13 embodied according to the invention.

All of the example embodiments of an inventive gas turbine component shown in Figs. 2 to 13 are static components for aircraft engines. The inventive components have a minimized weight, good thermal isolation characteristics, and are furthermore producible in a cost-advantageous manner. Arising vibrations can be surely and well damped via the metal foam.